Australasian Plant Conservation

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Special theme:
Community projects and citizen science

Monitoring of Marri canker disease | Revegetating difficult terrain | Citizen science program – monitoring vegetation | Canberra collaboration – Bossiaea and much more...

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Front cover: Friends of Mt Majura volunteers recording species diversity during Vegwatch training Nov 2014. Photo: J. Lynch.

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Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research, and diary dates are welcome. General articles on any plant conservation issue are most welcome.

The deadline for the September–November 2015 issue is Friday 14 August 2015. The special theme for the issue will be *Ferals*. Please contact the incoming editor, Paul Adam, if you are intending to submit an article: editor@anpc.asn.au (or p.adam@unsw.edu.au).

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From the editor

HUW MORGAN

Welcome to the Winter 2015 issue of Australasian Plant Conservation! This issue provides a suite of articles exploring the theme *Community Projects and Citizen Science*. For plant conservation projects requiring lots of hands and eyes, a coordinated and dedicated team of volunteers is often the best or only solution for ensuring project goals are realised. Articles in this issue provide a range of examples of skilled amateurs and passionate science-minded community members making important, profound and lasting contributions to the conservation of Australian native plants. This issue also contains the fourth instalment of **Dan Cole** and **Greg Siepen's** large scale reforestation series focusing on maintenance of new biodiverse plantings.

On behalf of the team of hard-working and talented office staff (**Jo Lynch** and **Carly Westbye**) and APC graphic designer (**Siobhan Duffy**), along with the ANPC Committee, I am pleased to welcome you to the first issue of the new-look *Australasian Plant Conservation*. We hope you enjoy the new layout which was designed to present a more contemporary style for the bulletin, as well as provide easier to read text and clearer headings. The new layout has also allowed our design team to fix a couple of technical shortcomings in the previous style – ultimately saving time and the sanity of those behind the scenes.

This issue marks a further milestone for *Australasian Plant Conservation*, as it will be the last for which I am Editor. With the ongoing demands of a young family and a day job, I have made the decision to step down from the humble Editor's word processor to realise extra time with my family and the bush. Taking on the Editor's role has been a fantastic experience – I have enjoyed it greatly and will look back on it with fondness. To the wise and supportive ANPC Committee members, and particularly to the bulletin team, I offer my sincere and warm thanks and very best wishes.

It is my pleasure to announce that the incoming Editor of *Australasian Plant Conservation* is **Paul Adam**. Paul is a pillar of native plant ecology and conservation research in Australia, and will bring a wealth of experience, knowledge and enthusiasm to the bulletin. Paul has particular expertise in the ecology of coastal plant communities, Australian rainforests, pollination, urban bushland and threatened species. He will make an excellent Editor and *Australasian Plant Conservation* and its readers will benefit immensely.

I wish you excellent reading!

Citizen science: Community monitoring of Marri canker disease

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Introduction

A successful citizen science project requires three primary components. First, a compelling research topic focused on an issue comprehensible by the broader community; second, an engagement strategy that communicates the issues and creates partnerships with scientists and the community; and third, efficient, flexible technology to implement the program.

Information is a key output of a successful citizen science project. Not only must the data be of high quality when captured but they must be easily accessible subsequently to both contributors and scientists. For community members this completes a feedback loop, allowing them to see the results of their efforts in a broader context. For scientists, the data must be available in a form fit for further analysis.

In this article we present the Marri Canker Project as a case study that:

- Addresses a specific environmental issue of interest to both researchers and the broader community.
- Engages with passionate community members who advise, learn and contribute data from the field.
- Utilises a smartphone app to aid identification and facilitate data capture in the field, improving both the quantity and quality of data being contributed to the project.

Background

Marri (*Corymbia calophylla*), an iconic, keystone tree species of woodlands and forests in the southwest of Western Australia, is suffering a major decline associated with the canker fungal pathogen *Quambalaria coyrecup* and the foliar pathogen *Q. pitereka* (Paap et al. 2008). Marri plays a major ecological role as a food source, habitat tree and refuge for numerous vertebrate and invertebrate fauna including the endangered Carnaby's Cockatoo (*Calyptorhynchus latirostris*), as well as being a key species for honey production in southwest Western Australia.

Attack by the canker fungus (*Q. coyrecup*) causes the death of areas of bark and the cortex tissue below that, resulting in cankers – localised areas of dead bark and wood. Cankers can be present on trunks, branches and twigs of trees of all ages. As the attack progresses, cankers girdle the affected limb or trunk, resulting in the death of the branch or entire tree. Diseased parts are also weakened to a point where they can be impacted by storms, with branches snapping or trees being blown over at the compromised canker site.

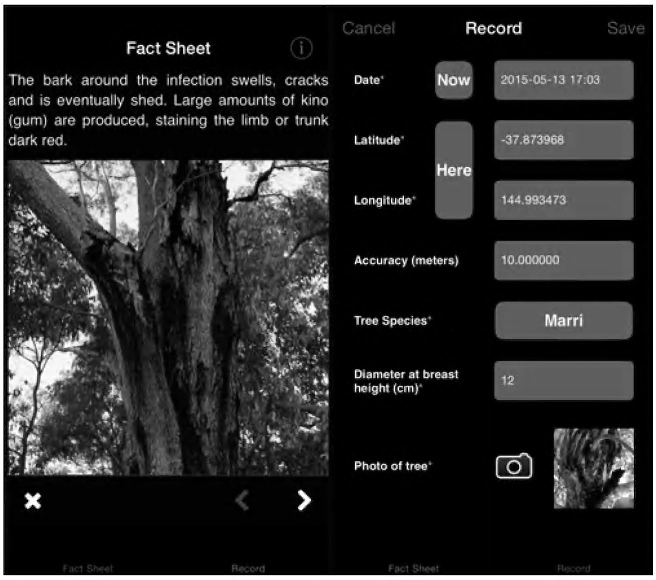
The foliar fungus (*Q. pitereka*) causes shoot blight in new shoots, leaves and flower buds, resulting in death of these tissues. This has serious implications for recovery of trees post-fire, and nectar and seed production for both native fauna and the WA beekeeping industry.

The impact of these pathogens is causing increasing concern across the community, and there has been substantial impetus and support from local communities to develop methods to manage these pathogens in the landscape.

The Marri Canker Project

In the Margaret River area, the Cape to Cape Catchments Group (CCG), local landowners and researchers from Murdoch University's Centre of Excellence for Climate Change, Woodland and Forest Health are collaborating to trial potential treatments for the canker disease. In 2014, seven trial sites were established by the CCG group together with local landowners. Each trial plot contained 80 canker-affected Marri trees. Within these plots, treatments of phosphite and nutrient implants were applied to diseased trees, with the aim of providing a 'health boost', enabling the trees to fight disease and halt disease progression. Treatments were applied by the landowners with assistance and training from scientists. The results from these trials will enable scientists to develop a better understanding of the effects these treatments have on the pathogen. Given the effort required to apply these treatments, this approach is considered an interim measure while researchers continue to investigate more viable long-term options.

In addition to these intensive treatments, a smartphone application called The Marri App was collaboratively developed by the Eastern Metropolitan Regional Council, Murdoch University and Gaia Resources to assist collection of Marri canker data by citizen scientists. The Marri App helps citizen scientists to identify and record disease symptoms on Marri, with embedded fact sheets providing users with images and information on the identification of cankers and shoot blight. The app can also be used to record the presence of healthy trees, adding further information to the database. The app captures GPS location, incidence and severity of cankers on trees, and also lodges photographs and other site information to a central data repository, providing valuable additions to current knowledge on the incidence of this disease. Citizen science volunteers can view their data in context with all the other contributions to the project via the project's Biological Data Recording System (BDRS) data repository, while scientists can manage, review and download all data.



Fact Sheet

The bark around the infection swells, cracks and is eventually shed. Large amounts of kino (gum) are produced, staining the limb or trunk dark red.

Record

Date* 2015-05-13 17:03

Latitude* -37.873968

Longitude* 144.993473

Accuracy (meters) 10.000000

Tree Species* Marri

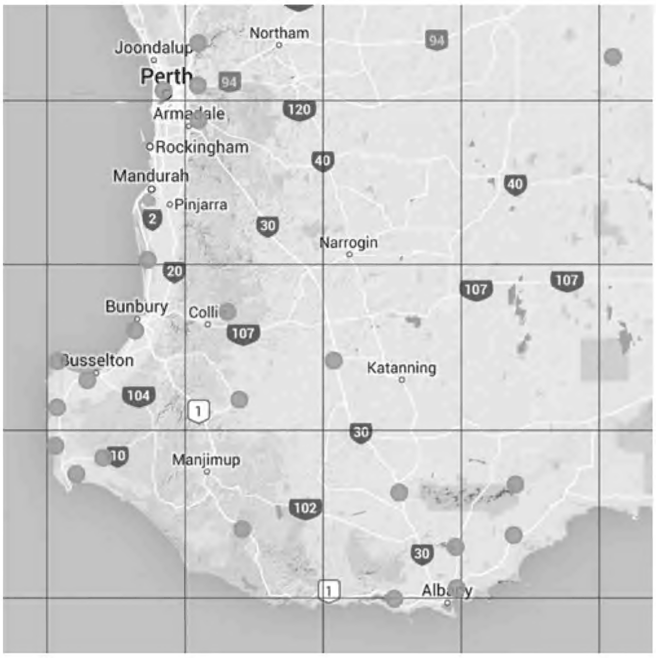
Diameter at breast height (cm)* 12

Photo of tree*

Screenshots of The Marri App illustrating aspects of the fact sheet and data recording functionality.

Marri Canker Project results

Since its launch in December 2013, 138 registered users have contributed 366 observations from a range of regions across the southwest of WA. These comprise 335 trees across 31 sites. Over 300 images have also been submitted, providing documentation of the disease, a reference point for correct diagnosis, and a potential baseline for measuring the outcomes of subsequent treatments.



Locations where The Marri App has been used to collect information on marri canker presence.

Discussion

Impetus for developing the Marri Canker Project came from members of the community who were observing decline in their local Marri populations and calling the plant pathologists at Murdoch University – already researching the disease – seeking answers and potential treatments. In this way it was a grass-roots driven project, considered one of the main reasons funding was subsequently obtained to start the collaboration.

So in this case, the environmental issue was perceived by the community that led to engagement with scientists and then funding bodies. Community members provided an existing 'network of enthusiasm' able to be engaged to collect the large-scale research data required for scientific analysis.

Some of the lessons learnt over the period of the project so far include:

- Roles of each partner agency must be clearly defined, especially with regards to project ownership, coordination, training and publicity.
- The development and maintenance of a successful smartphone app requires significant resources, including for engaging with app developers to specify requirements and define functionality and ensuring adequate support for the app subsequent to its release.
- Training helps deliver the best from volunteers. In the case of the Marri Canker Project, volunteers were provided training in both project research methods and smart phone technology.

This citizen science project, together with the deployment of The Marri App, has provided ongoing engagement with concerned members of the community in both rural and urban regions. More than just education and outreach, it has allowed large scale data collection that would otherwise be a laborious and costly research impediment. The contributed data for 335 trees across 31 sites is now in the process of being analysed by research scientists to understand the decline process and test potential treatments with the aim of developing sustainable management solutions. This project has already served as a model in setting up a new 100 tree treatment trial currently being undertaken in the Shire of Mundaring, east of Perth, also in conjunction with the Eastern Metropolitan Regional Council.

Acknowledgements

With thanks to the Eastern Metropolitan Regional Council, the Western Australian Government's State Natural Resource Management Office and the citizen scientists of the Cape to Cape Catchments Group.

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Links

The Marri App for Android: v1.0.5, 22 Feb 2015: https://play.google.com/store/apps/details?id=com.gaiaresources.bdrsmobile.murdochmarri

The Marri App for iOS: v1.0.1, 07 April 2015: https://itunes.apple.com/au/app/the-marri-app/id742004918

Unravelling the secrets of the Crowded Leek Orchid: a partnership between volunteers and business

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Introduction

The Crowded Leek Orchid (*Prasophyllum crebriflorum*) was discovered serendipitously in 1999 at Westwing Plain in north-western Tasmania. When it was described in 2003 the known range extended to another sub-alpine grassland, both at the privately owned Surrey Hills estate (Jones 2003). In 2008–09, Cradle Coast NRM funded a project to initiate demographic monitoring of *Prasophyllum crebriflorum* and to increase community involvement.

The community group Threatened Plants Tasmania (TPT, a part of Wildcare Tas Inc), together with the Tasmanian Department of Primary Industries, Parks, Water and Environment and the Resource Management Team (RMT) at Forico Pty Limited (then Gunns Ltd) agreed to collaborate on a demographic monitoring project. The first monitoring survey was completed by TPT volunteers and RMT in 2010. This was soon followed by another serendipitous discovery: a new population of *Prasophyllum crebriflorum* at nearby Knole Plain. This provided the impetus to expand the project to include regular extension surveys, especially in recently burnt grassland. Observations from the monitoring program has presented a number of conundrums, which we have sought to resolve through additional structured surveys.

Management

During the 1990s the previous forest owners recognised that native grasslands in the Surrey Hills Estate were of conservation significance, supporting several threatened plant species, the Ptunarra Brown butterfly (*Oreixenica ptunarra*) and other threatened animal species. In 1998 a management plan was developed covering weed and fire management prescriptions, disturbance and monitoring. In particular, to avoid the autumn flying season of the Ptunarra Brown butterfly, it was determined the grasslands should be burnt in early spring, sometimes a challenge in this wet part of Tasmania. The RMT enthusiastically embraced the plan and, for their efforts, won the 2006 *Australian Environment Foundation Award for Environmental Management in Forestry* (Davey and Duncan, 2006). In 2010 almost 4700 ha was reserved in either a Covenant or Vegetation Management Agreement and the new owners Forico continue with the same commitment to manage the grasslands.

Crowded Leek Orchid (*Prasophyllum crebriflorum*) flower spike, with an unidentified visitor. Photo: Phil Collier.

Surveying

From 2011, the annual monitoring visit to Surrey Hills by TPT volunteers has often included a day or two of extension surveys for new populations of *Prasophyllum crebriflorum*. Members of the RMT keep their eyes out for potential sites, especially in recently burnt grasslands. These surveys tend to focus on potential habitat between the original site at Westwing Plain and Knole Plain. This axis contains most of the newly discovered populations, with one outlying population to the north at Peak Plain.

Surveys from 2009 to 2012 had been opportunistic, essentially random walks through potential habitat, recording GPS data where orchids were found. After discovering a population of flowering plants at newly burnt Hatfield Plain in January 2012, we re-visited in January 2013 for a more structured population count. In the central portion of the plain, we created a rectangular survey area 300 m × 500 m, covering 15 ha. This was divided into 6000 5 m × 5 m adjacent survey plots that combine to cover the survey area. Sixty of these plots were randomly selected to be visited.

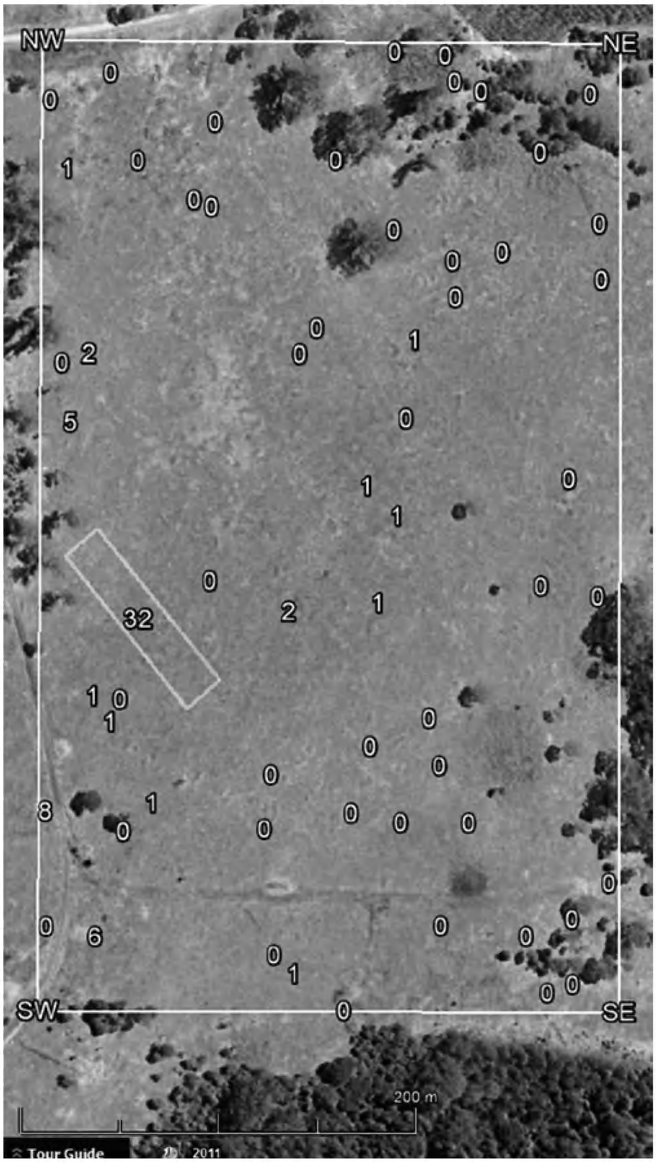
Teams of three or four volunteers were provided with a GPS containing waypoints for the south-west corner of their allocated survey plots, four steel pegs and a measuring tape. Volunteers were instructed about how to peg out their allocated 5 m × 5 m rectangular plots using their tape, and then count the number of *Prasophyllum crebriflorum* plants within. Unfortunately some teams found no plants in any of their plots, which was not ideal for morale. This also reflected an uneven distribution of plants across Hatfield Plain, increasing the error in the population estimation. Assuming that all plants in the survey plots were detected, the population estimate for the survey area is 3200 ± 2243 plants (95 per cent confidence) or 3200 ± 1874 plants (90 per cent confidence).

Monitoring

Monitoring has been conducted annually by TPT and RMT at Westwing Plain from 2009-10 until 2014–15. The plain was burnt in September 2008, prior to the establishment of monitoring, followed by a patchy burn in June 2012, followed by an extensive burn including neighbouring plains in November 2014. We visit Westwing Plain at least annually – at flowering time in late January, and sometimes more frequently.

In 2009, 80 plants were tagged, mostly in leaf, and observations made on two subsequent visits found 67 of these plants had been grazed to the ground. In 2012, we visited Westwing Plain in early December to recover tags in the burnt area, and measured all emerged leaves. By flowering time, many leaves had again disappeared. In 2014, we monitored flowering in late January and fruiting in early February, again finding many plants had been grazed between the visits. On the basis of these experiences, we created models of grazing, with the best fit suggesting that grazing pressure increases during the growing season, and few if any plants survive to produce fruit. Additionally, larger leaves primed for flowering in 2012–13 were located in the burnt areas, and these are preferentially grazed (Collier 2013). Fortunately, the grazing recorded in 2014–15 was less severe, when a larger burn area had possibly diluted the grazing pressure.

One of the puzzling results of the monitoring is that the proportion of previously tagged plants that flower each year is very low, being well under 10 per cent in the last three years even after the burns. However, there are often 20 or more untagged flowering plants each year at Westwing Plain, some of which we tag for future reference. This leads to a suggestion that plants are relatively short lived, with the presumed dead plants being replaced by new plants. Clearly not all orchid fruits are grazed. In order to investigate this systematically,



Hatfield Plain, showing results of the systematic population survey in 2013 at randomly selected survey plots and the 'cricket pitch' with 2013 count.

we created the Hatfield Plain 'cricket pitch', a 100 m × 20 m quadrat in which all flowering plants are counted annually. As always with monitoring, secrets are unravelled slowly, complete with surprises along the way.

TPT Volunteer benefits

Prasophyllum crebriflorum plants reach peak flowering around the January long weekend. Combined with a very attractive sub-alpine grassland location and comfortable accommodation provided by Forico, field trips provide an enjoyable experience, apart from the leeches. The active participation of the RMT is a unique dimension of these trips, with the opportunity to discuss weeding and disturbance with professional land managers who have the strategy, resources, operational capability and good humour to manage the precious grasslands and surrounding forests effectively.

Business benefits

Forico continue a long standing relationship of Surrey Hills land managers with threatened species specialists that is beneficial to both parties and the ecosystems they intend to preserve. There have been numerous research studies on the grasslands over the past 40 years with the land managers encouraging access and assisting wherever possible in an attempt to monitor the effectiveness of the land management practices being performed. This long term community involvement has led to the reservation of these critical habitats and demonstrates the importance placed on natural vegetation areas.

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When is a Yam Daisy more than a Yam Daisy? When is a grassland more than a grassland?

PAUL GIBSON-ROY

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I recently attended two forums linked to the release of the grassland book *Land of Sweeping Plains: Managing and restoring the native grasslands of south eastern Australia*. The first was at the Royal Botanic Gardens Melbourne and the second at the Australian Nationa Botanic Gardens in Canberra. Both were celebrations in a sense, focusing on the tremendous work and effort that has gone into conserving and restoring our perilously threatened grasslands and grassy woodlands. Associated with these two forums were many fine presentations focussing on this species of plant or that species of critter. All were very interesting and contributed to our knowledge of these systems (and perhaps how to conserve or restore them). And while it is clear from the many years I have attended workshops and forums on restoration, that often as a sector we tend to focus very intently on species (i.e. threat status, seed morphology, fodder potential, habitat requirements etc), it was refreshing and beneficial to hear at these forums from several speakers who spoke about grassland species in a different context.

A particular example was Aileen Blackburn and three of her young trainees – Brook, Rene and Markita – from the Eden Local Aboriginal Land Council, who presented on the Bundian Way project. The Bundian Way is pathway long used by Aboriginal peoples, which connects the Kosciuszko region to the coast. Along this pathway, Yam Daisy (*Microseris lanceolata*) held great importance for the local people, especially the women. The Yam Daisy is a plant most people automatically associate with Aboriginal culture and its importance as a food crop. In *Land of Sweeping Plains*, Gott et al. (2015) refer to the cultivation and use of this and other species. They also provide insight into the commonness of the Yam Daisy, citing George A Robinson from 1840 who described the Basalt Plains of Western Victoria as a landscape covered in millions of Yam Daisies or Murnong (the local Aboriginal name for them). Sadly, like most ground layer species and despite its historic importance to Aboriginal culture, the Yam Daisy is no longer common or widespread. Even from my own personal experience having spent over a decade traversing this region in some detail, I know of only several small and one large population of Yam Daisy on the Basalt Plains. I have also grown it in large numbers in Seed Production Areas, and in that context often viewed its tuberous nature. So, it was with great interest that I listened to Aileen's presentation. Also, I don't think I was alone in expecting its focus to be primarily on its food use, and while this was of course raised, I was very pleasantly surprised to realise the Yam Daisy meant much more to Aileen and her trainees Brook, Rene and Markita than that.

Lifted Yam daisy tubers from a Seed Production Area being washed prior to re-planting. Photos: Paul Gibson Roy

Aileen spoke with passion of the deep ancestral connections her people had in relation to the Yam Daisy. Rather than a discourse on the use of the yam, she touched more and more instead on the human connections that bound them to the Yam Daisy. Aileen stressed the importance of the yam fields because for her, they represented a joyous and important meeting place for Aboriginal women – one that stretched back unbroken for countless generations. It was in these yam fields that, in addition to tending and harvesting the plants as a food crop, the women held important ceremonies, told stories and shared time together. What really struck a chord with me was how important Aileen felt the Yam Daisy fields were to her deep and loving connection between herself and her mum and her Nan. It was clear that the bonds forged between her and relatives were intimately tied to those plants.

At one point Aileen and the trainees showed the audience traditional implements used by the women to dig and cultivate Yam Daisy. There were three quite lovely and ornate wooden diggers of varying heights – short to long essentially. I think many in the audience (myself included) thought these differences in the length would in some way relate to the peculiarities of extracting the yam itself, but no. With wry humour Aileen told us that the longest diggers were reserved for the older women – so they could tend the crops without having to bend too much. The middle sized diggers went to the middle age women, the mums and the aunties I guess, who still had a bit of back flexibility. And of course the shortest diggers went to the young girls, who were most able to bend, and invariably needed more time honing their yam extraction skills under the tutelage of their esteemed elders. This explanation was very amusing to the audience. To me, her explanation of the reasons for digger design highlighted how easy it is to fall into a trap of seeing these species in a very narrow focus, such as their threat status, or their utility as fodder or for carbon sequestration. It seems we rarely see their potential to act as conduits for human interaction. In this respect, Aileen's presentation showed beautifully how plants connected people.

Later, Adrian Marshall gave a lovely presentation that in many subtle ways (at least I thought so) was similar to Aileen's. Adrian spoke with great passion and insight about how native grasslands could and should be used within contemporary urban landscapes. He used some spectacular examples of native species being used as the basis for vibrant and inviting urban parks and landscapes. The City of Hume in northern Melbourne for example has supported clever artistic and landscape use of grassland plants and animals in that region. For example, the city built a very popular children's playground called the 'Golden Sun Moth Playground' featuring a huge and colourful metal moth which children climb and play on. These new urban landscapes dotted throughout the City of Hume and other parts of Melbourne's west are constructed to feature – rather than supress – native grasslands. They are also meant to be happy and relaxing places for people to gather and socialise. Like the Yam Daisy fields along Aileen's Bundian Way, these modern urban grasslands are places that bring plants, animals and people together.

So, when is a Yam Daisy more than a Yam Daisy, or a grassland more than a grassland? These two presentations served to remind us that this can be the case. They highlighted how involvement with our wonderful native plant and animals creates unique opportunities for people themselves to connect, not only with each other in the here and now, but also through links into our past and as bonds forged with future generations.

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Democratisation of biological collections: developing an online image herbarium for mine rehabilitation sites in Queensland

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Introduction

Recent advances in information technology are bringing light to the mature scientific discipline of botany and scientific collections. Few can question the phenomenal impact technology has had in allowing digitisation of scientific collections (Beaman and Cellinese 2012) and the substantial shift in the way we interact with data. Until fairly recently (the last decade or so), many biological collections were kept in naphthalene-infused vaults of herbaria and museums, rarely seeing the light and then only for selected professionals. Access to these publicly-funded resources has historically been restricted and retrieval of specimens and vital associated metadata was time consuming.

Substantial investment in the digitisation of many herbaria around the world including Australia (e.g. *Australia's Virtual Herbarium*), has been undertaken in recent years, which has substantially improved dissemination of information through web portals such as the *Atlas of Living Australia* (http://www.ala.org.au) and the *Global Biodiversity Information Facility* (GBIF: http://www.gbif.org). Digitising these collections and making them available can however require considerable investment of time and resources (Jones et al. 2014).

Currently, there are 82 operating mines in Queensland (Geosciences Australia 2015), and most have requirements to rehabilitate mined land following mine closure. Many of the operating and closed mines coincide with the bulk of our collections (e.g. Bowen Basin, Mt Isa), hence there should be an increasing demand for resources to inform rehabilitation efforts.

This paper reviews new opportunities to digitise biological reference collections such as plant specimens, using relatively low-cost hardware, software and volunteer effort. Additionally, we outline our experience with recent upgrades to our small but very functional herbarium and share some of our learnings.

Upgrading a small but functional herbarium

The Centre for Mined Land Rehabilitation (CMLR) conducts multi-disciplinary research to inform a wide range of mine rehabilitation and environmental management decisions. Plant identifications by CMLR staff and students are a fundamental step in assessing the effects of mining and success in rehabilitation of disturbed land. Environmental monitoring often involves extensive plant identifications, especially in the initial years at new sites. Additionally, a number of locations where we work have limited plant identification resources available. This particularly applies to central Queensland for which there is no comprehensive flora – in contrast to south-east Queensland and NSW.

Since the inception of CMLR some two decades ago, many researchers have collected specimens across many mine sites in Queensland and NSW and validated specimen identity with botanists at the Queensland Herbarium and National Herbarium of New South Wales. There are approximately 4000 specimens in the collection, varying in condition and quality of collection data. The CMLR Herbarium is a purpose-built single-room facility constructed in 2006. It was designed to house specimens with its own closed-circuit air conditioning system to regulate temperature and humidity for the preservation of dried plant specimens. Plant collections were stored in folders arranged by site without a central database. Development of new projects required more effective access to plant identification resources, and one way to achieve this was to digitise the collection so that existing specimens could be searched and examined without needing to access the original specimen.

In 2012, a substantial upgrade of the herbarium collections management system and identification resources was enabled as a component of an industry grant. This included the purchase of an imaging microscope, a dissecting microscope, two computers, a copy stand and camera, shelving, archive boxes, plant presses and mounting equipment. During these upgrades, we found out that there are few 'off the shelf' herbarium materials which readily met our requirements.

We had to have archive boxes custom made, shelving made to fit the boxes, and we sourced other materials such as mounting card from local and overseas suppliers. We provide more detail on our website to assist anyone needing to source herbarium supplies https://www.cmlr.uq.edu.au/cmlr-resources.

Digitising the plant collection

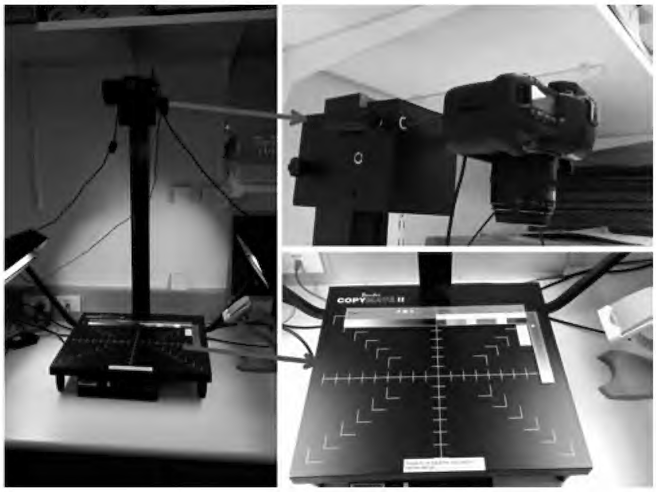
The aim of the CMLR Herbarium is to assist with plant identifications by providing query-based filtering of specimens and dynamic high-resolution images to complement traditional forms of identification such as flora books and keys. The collections cover flora found at mine site locations primarily in Queensland but with some collections covering NSW and Northern Territory. Whilst the collection will remain small, it does provide advanced features and capabilities compatible with Australian and global herbarium online initiatives. It is also publicly available for others working on mine sites or interested in plant identifications.

The online herbarium has been developed with SilverBiology (http://www.silverbiology.com/) and CMLR. Specimen processing and digitisation was undertaken by CMLR staff, summer students and volunteers. In fact, without the enthusiasm and efforts of students and volunteers, the project would not have been able to process the number of specimens completed.

There are a vast range of specimen image capture techniques, biological collection management systems (e.g. Specify http://specifyx.specifysoftware.org/, BRAHMS http://herbaria.plants.ox.ac.uk/bol/) and portals and aggregators (e.g. iDigBio 2015, Nelson et al. 2012). A number of institutions and organisations also develop their own image digitisation systems. We chose to partner with the small US company SilverBiology which provides an 'off the shelf' solution for imaging and populating the virtual herbarium database for people without relational database experience.

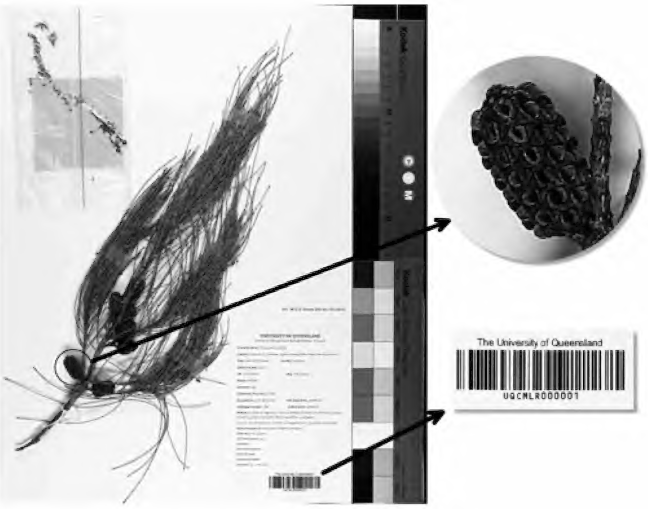
We used the software tool SilverImage to image specimen sheets from a copystand setup configured to work with the software. The digitisation workflow followed five task clusters (see Nelson et al. 2012):

1. Pre-digisation curation: preparing specimen, placing barcode.
2. Photograph specimen.
3. Specimen image processing: scan barcode, batch process multiple photos
4. Electronic data processing: upload of spreadsheet data and import to SilverCollection software.
5. Georeferencing specimen data: often included in the step above.



Copystand large enough to fit A3-size paper. A full-frame Canon 5D Mark II digital SLR camera is held at the top of the stand, and the benchtop includes metal angle and colour reference patches to enable batch processing of images. Photos: N. McCaffrey.

High-resolution images are then uploaded and displayed via the interactive web portal SilverCollection using the MySQL database platform. With some specimens, there was a collections management spreadsheet but for some older specimens, these required a semi-automated step of optical character recognition (OCR) of the specimen data label or manual entry if handwritten. Without a dedicated collections management software package, we simply combined all specimen occurrence data into a spreadsheet which is consistent with Darwin Core (http://rs.tdwg.org/dwc/), an international body of standards which facilitates integration with other online repositories such as GBIF and Atlas of Living Australia (ALA) (http://www.ala.org.au). The CMLR Online Herbarium can be accessed from: http://cmlr-herbarium.smi.uq.edu.au/collection/.



Example specimen image (*Allocasuarina distyla*). Images can be viewed interactively to high resolution using same 'tiling' technology used by Google Earth. Images include custom barcode identification made using a cheap labeller. Photos: N. McCaffrey.

Conclusion

Whilst our collection is small, it does provide an example for any large or small herbaria looking to digitise their collections. The CMLR Online Herbarium also provides a representative collection of plants commonly found throughout the active mine sites of Queensland and beyond to promote publicly available biological data.

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Murrumbidgee Bossiaea – a Canberra collaboration

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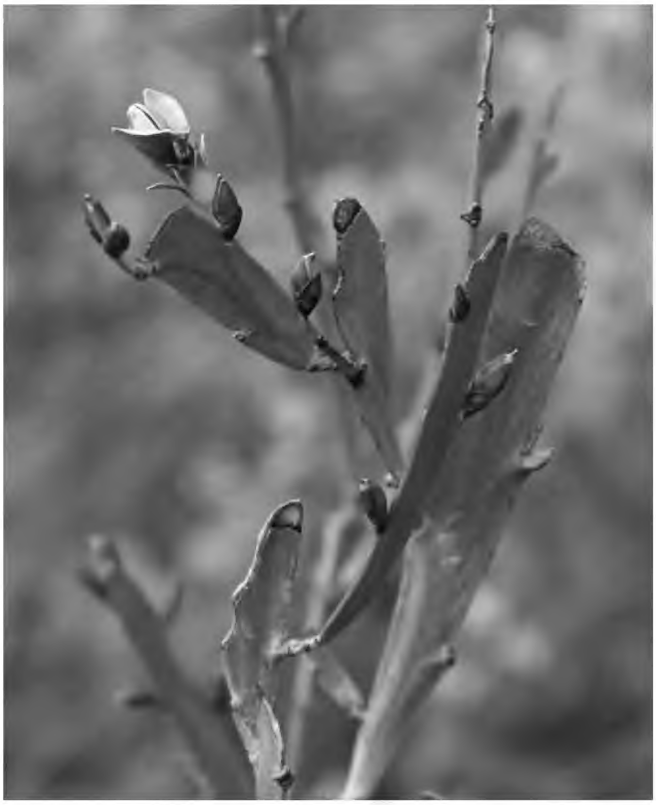
Murrumbidgee Bossiaea (*Bossiaea grayi*; McDougall 2009) is a threatened species endemic to the ACT which occurs along the Murrumbidgee, Paddys and lower Cotter River corridors. It is a shrub to 1.5 m high with leaves reduced to scales and flowers and pods borne on flattened cladodes. The species has been recorded previously within the lower Molonglo and upper Queanbeyan River corridors but these populations have not been found in recent surveys. The main driver of where populations occur appears to be landscape position and soil type, with all sites located within incised river valleys, mostly on steep, rocky and skeletal (well-drained) soils.

Murrumbidgee Bossiaea was declared endangered in 2012 under the ACT *Nature Conservation Act 1980* because it was assessed to be at risk of premature extinction due to a severely fragmented distribution, small range or small area of occupancy within that range. The total number of plants occurring in 11 disjunct populations has been estimated to be between 2700 and 2900, but a number of these populations are small (one to 11 individuals). Threats to the species include competition from native shrubs and weeds, potential disturbance from pine forest harvesting and plantation management, proximity to recreational areas and vehicular access tracks, and hydraulic disturbance (bank undercutting and flooding). All populations were burnt in the 2003 Canberra bushfires.



Murrumbidgee Bossiaea in flower and bud near Paddys River on 12 September 2014. Photo: Alison McInnes.

Major conservation objectives for Murrumbidgee Bossiaea are to maintain viable, wild populations and manage habitat to maintain natural ecological processes (ACT Government 2013). Strategies for achieving this include supporting appropriate seed banking and establishment of *ex situ* reserves of the species, and undertaking research to gain a better understanding of seed production and seed germination. Seed collection and germination trials are currently being conducted by volunteers from the National Seed Bank, Australian National Botanic Gardens (ANBG) with support from the Australian Native Plant Society (ANPS) Canberra Region. The volunteer work program is guided by staff from the National Seed Bank, ANBG and Conservation Research, Environment and Planning Directorate, ACT Government.

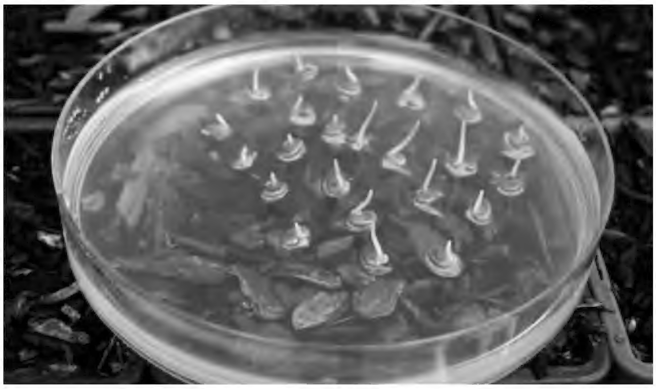
Pods of Murrumbidgee Bossiaea dehisce (naturally split) explosively around December when they reach maturity and therefore need to be collected by bagging. Bags were sewn by seed bank volunteers and in November 2014, volunteers, ANBG seed bank staff and ACT Government staff bagged branches on 120 plants in the two largest populations of Murrumbidgee Bossiaea.

Bags containing dehisced seed and pod material were removed from the branches by ANBG staff and seed bank volunteers. Harvested materials were initially cleaned by hand to remove pod material and any insects, and then further cleaning was undertaken to provide seed for storage in the National Seed Bank and for germination trials. There are now 21 965 seeds secured in *ex situ* storage at the National Seed Bank to buffer against the loss of plants in the wild. For the stored seed to be utilised effectively under such circumstances it is essential to understand the germination requirements of the species.

Many Australian legume species are hard seeded (physically dormant), requiring disruption of an impermeable seed coat to allow imbibition of water and germination to take place. Germination in other species of *Bossiaea* is known to be promoted by manual or mechanical scarification of the seed coat with sandpaper, manual nicking of the seed coat, microwaving, exposure to dry heat, application of boiling water and application of steam heat to the soil seed bank (Morrison et al. 1992, Ward et al. 1997, McPhee 1998).

Margaret Clarke, ANBG National Seed Bank Volunteer, collecting seed bags of Murrumbidgee Bossiaea from Paddys River, ACT. Photo: Tom North.

In March to April 2015, seed from the largest Murrumbidgee Bossiaea population was treated to promote germination by manual scarification with glasspaper, microwaving, and immersion in hot water (95°C for 2 minutes). Treatments were compared with the germination of untreated seed (the control). Seed from all treatments including the control group was surface disinfected in ethanol and bleach. All treatments improved germination relative to the control, with immersion in hot water resulting in the highest mean number germinating. A second trial is underway to determine whether manual nicking of the seed coat with a scalpel can improve the proportion and rate of germination relative to seed immersed in hot water. Seed germinated in the trial is being propagated by the ANPS Canberra Region and plants will form an *ex situ* population located in ANPS members' gardens to further ensure the future of the species.



Germinated seed of Murrumbidgee Bossiaea is most easily planted when emergent radicles are around 1 cm in length or less. Photo: Alison McInnes.

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Seedballs: a useful tool for revegetating difficult terrain?

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What are Seedballs?

Seedballs are seeds rolled within a clay and soil mixture. They can be planted or broadcast. Over time the seeds germinate, utilising the soil mixture in the seedball. In the meantime, the clay may protect the seeds from desiccation, predators, and loss from the site to wind and water (Jones 2012). Seedballs can be used where more conventional planting or seeding methods may be inappropriate or cost prohibitive, e.g. where rainfall is erratic or it is difficult to dig, rip or direct seed. Another advantage of seedballs is that making and distributing them can be an enjoyable activity for community volunteers, with the hands-on process suitable for people of all ages.

Community volunteers making seedballs. Photo: Greening Australia.

Modern use of the technique originated in Japan during World War II and more recently seedballs have been trialled in other parts of the world (e.g. Jones 2012, Overdyck 2013). There are numerous popular accounts of making and using seedballs (e.g. Bones 1996), however a survey of the scientific literature revealed very little rigorous monitoring of the method's effectiveness. We decided to trial the use of seedballs, to see whether any local native plants showed promise using this method in the south-east Australian context.

Making and placing seedballs

With the assistance of volunteers, we made four types of seedballs with a range of seed types. These four seedball types contained:

- *Eucalyptus* species: Apple Box (*E. bridgesiana*), Broad-leaved Peppermint (*E. dives*), Red Box (*E. polyanthemos*) and Scribbly Gum (*E. rossii*).
- Species with fluffy seeds: Australian Blackthorn (*Bursaria spinosa*), Shiny Cassinia (*Cassinia longifolia*) and Sticky Everlasting (*Xerochrysum viscosum*).
- Grasses: Corkscrew (*Austrostipa scabra*), Red-leg (*Bothriochloa macra*), Weeping (*Microlaena stipoides*) and Wallaby (*Rytidosperma caespitosum* and *R. pallidum*).
- Species with hard-coated seeds: Box-leaf, Red-stem and Silver Wattles (*Acacia buxifolia*, *A. rubida* and *A. dealbata*) and Wedge-leaf Hopbush (*Dodonaea viscosa* subsp. *cuneata*).

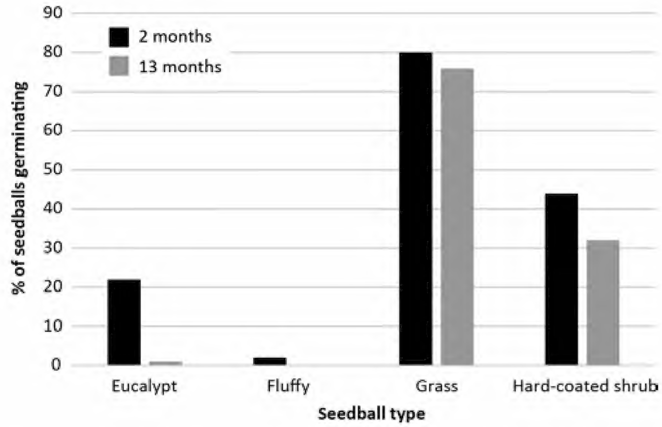
Seedballs were made by mixing one part seeds (see www.greeningaustralia.org.au for proportions of each species per seedball) with three parts of a commercially available native seed raising mix, five parts Kaolinite clay and two parts water. This mixture was kneaded to the consistency of bread dough. Seedballs approximately 20 mm in diameter and weighing around 10 grams were then rolled between the palms for 10 seconds to force out air and make a smooth, round ball. Lastly these balls were dried on a tarpaulin for at least 24 hours.

We trialled seedballs in the Lower Cotter Catchment in the ACT, 20 km south west of Canberra. Mean annual rainfall in Canberra is 615 mm, approximately evenly distributed throughout the year. Rainfall events are often interspersed with long periods of dry weather (Bureau of Meteorology, 2014). Two sites within this area, on closed gravel roads, were selected to conduct the trial. The ground at these sites was compacted from vehicle use, and grasses and forbs occupied on average a quarter to half of each plot area.

At each site, in October 2010, we distributed 100 seedballs of each of the four types in a plot, then replicated this arrangement three times. We placed seedballs on a grid, with a distance of 500 mm between them. They were placed into small depressions approximately 10 mm deep made with a mattock, meaning the seedballs were half-buried. Thirty randomly selected seedballs from each plot were monitored two and 13 months after placement, in December 2010 and November 2011.

A success story for shrubs and grasses

Two months after placement, we found there was some germination from each seedball type. Grass seedballs germinated most frequently with over three-quarters having at least one germinant. Hard-coated shrub species also germinated frequently, with over 40 per cent germination. Less than a quarter of eucalypt seedballs showed any germination, while fluffy seedballs showed very little germination.



Percentage of seedballs with germinants or seedlings after two and 13 months (as observed in December 2010 and November 2011).

At 13 months, approximately three-quarters of grass and a third of hard-coated shrub seedballs had germinants or seedlings. Of the shrub germinants, Wedge-leaf Hopbush was the most successful, making up 65 per cent of germinants. The remaining 35 per cent of shrub germinants were *Acacia* species. There were very few eucalypt and no fluffy seed germinants. Over these 13 months, rainfall was 50 per cent higher than the historical average with the wettest period during the first four months after planting, followed by drier than normal conditions through autumn and winter.

We conducted a second assessment in October 2012, two years after the initial trial. At this time, no eucalypt or fluffy germinants were found. In addition, no meaningful data could be collected on the grass seedballs, as it was not possible to determine whether the grasses had germinated from the seedballs or from other seed sources. At two years, 21 per cent of hard-coated shrub seedballs had produced seedlings. These seedlings were made up of Wedge-leaf Hopbush (45 per cent) and the three *Acacia* species (55 per cent).

Wattle germinating from seedball. Photo: Greening Australia.

Future use of seedballs in Australia

We undertook this experiment as a trial of the seedball concept in our region, to determine which genera are worth testing further. The substantial germination of grasses, acacias and hopbushes, and their persistence to at least a year later, suggests seedballs should be further considered as a method of revegetating with these species. On the other hand, while eucalypt seedballs produced some early germination, these germinants did not survive to one year. Eucalypts appear thus unsuited to use in seedballs. The species with fluffy seeds produced virtually no germination and are not considered candidates for further use in seedballs.

These results broadly correlate with Greening Australia's experience using these different seed types in conventional hand seeding and mechanical seeding situations. Large-seeded wattles and hopbushes tend to germinate and persist well in comparison to fine-seeded eucalypts and thus require significantly less seed by weight to achieve desired results (Rayner 2010). A next step would be to directly compare shrub and grass seedballs with hand seeding or mechanical seeding the same species, to determine the cost effectiveness and establishment success of the different methods. However, we expect that seedballs would most often be used in situations where alternative means of seeding are inappropriate, such as where it is difficult to dig, rip or direct seed; on such sites it would be hard to test other seeding methods.

Our results point to the need to continue monitoring in seedball trials beyond the initial stages of germination to determine how well seedlings persist and establish. This is particularly important where rainfall is variable from year to year, with Jones (2012) finding more abundant germination from seedballs in the second growing season than the first.

Lastly, this investigation illustrates the important role the community can play in practical adaptive science. This investigation of seedball effectiveness involved volunteers in every step in the process, from making and distributing the seedballs, through to monitoring survival rates and analysing data. A truly amazing contribution!

Acknowledgements

Many thanks to the volunteers who made and distributed the seedballs, to the ACT Government for supporting the trial, and Stephen Thompson and Susie Wilson for their early contributions.

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Vegwatch: a citizen science program for monitoring vegetation condition

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The Vegwatch Program

It is now generally expected that monitoring will form part of any program that undertakes management aimed at enhancing habitat. However, many ecologists have warned that monitoring projects are very likely to fail if they are not well designed (e.g. Lindenmayer and Likens 2010). The Vegwatch program is a community science monitoring program facilitated by the Molonglo Catchment Group (MCG), developed to ensure it could be undertaken effectively by non-scientists. Vegwatch was developed with assistance from the Australian Government's Caring for our Country and the ACT Government, and complements the Frogwatch and Waterwatch programs.

Vegwatch was established to track the condition of bushland sites throughout the Molonglo River catchment, so that vegetation condition within and between sites can be compared over time. The program encourages volunteers and landholders who undertake on-ground work to monitor vegetation to assess the results of their labour, quantitatively measuring how actions they have applied on the ground have resulted in changes to vegetation composition, structure, function and habitat. The results can then be used to compare change over time within particular sites as well as over multiple sites within the region, significantly increasing the value and strength of individual studies.

The Vegwatch Manual

The methodology to support the Vegwatch monitoring program is published in The *ACT Region Vegwatch Manual: Vegetation and habitat condition assessment and monitoring for Community* (the Manual) (Sharp and Gould 2014). All the methods in the Manual have been designed to be used by people with limited scientific experience. The methods were tested by groups of (very patient) volunteers over a two year period before finalisation of the Manual. The Manual's guidelines for data collection are aligned with those commonly used by other vegetation monitoring programs, enabling direct comparison of data with other studies or frameworks (for example, NSW BioMetric indicators; NSW DECCW 2011). Floristic value scores (Rehwinkel 2015) may also be calculated from these data.

Under Vegwatch, vegetation condition is determined from the following components: plant species diversity, structural diversity, condition of native trees and shrubs, species cover and terrestrial habitat condition. Training is provided to maximise the quality and utility of data. MCG provides a central repository for the data for analysis and reporting.

Applying the Vegwatch program

The Molonglo Catchment Group has provided training and materials for 18 Parkcare groups within the ACT to establish Vegwatch monitoring. Other groups such as Friends of Grasslands have also established Vegwatch monitoring sites. To ensure compatibility and standardisation of data the users undertake the program each year in mid spring, when species diversity is likely to be at its maximum and herbaceous species are easier to identify.

The Draft Molonglo Catchment Strategy 2015–30 (Molonglo Catchment Group 2015) identifies Vegwatch as a critical tool for the strategy. Vegetation condition data are used to assess achievement of both individual projects and overall programs against the strategy's overall condition targets. MCG is seeking funds to put the results on a website, to help community groups track changes and to publicise the outcomes.

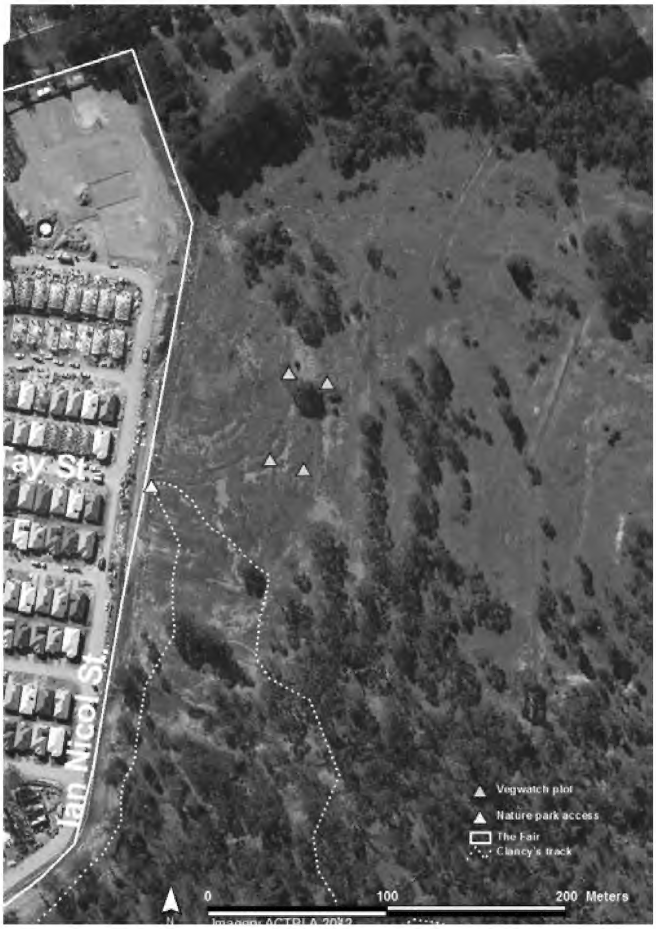
Friends of Mt Majura: a case study

In November 2014, a Vegwatch plot was established in the Mount Majura section of Canberra Nature Park. Over three morning sessions, all relevant indicators were measured by volunteers from the Friends of Mount Majura (FoMM) ParkCare Group, with assistance from the Vegwatch team. The site comprises critically endangered Yellow Box – Blakely's Red Gum Grassy Woodland that has been heavily impacted by past clearing, grazing and motor sport activities. It has been a major focus of ecological restoration for FoMM since 2012, including weed control, direct seeding of native grass and local forbs, and planting of a limited number of species of trees, shrubs and groundcovers.

The most significant management issues are weeds, soil erosion and compaction, rabbits and over-grazing by kangaroos, all of which contribute to low natural regeneration of native species. Consequently, much revegetation with local native species has been undertaken over the last four years, with tree guards and woody debris (tree branches) placed around plants to reduce grazing impacts, as well as to encourage natural regeneration.

The results of the Vegwatch monitoring were very encouraging for such a degraded area. Despite the fact that some native species were introduced through revegetation, the volunteers were surprised by how many species were recorded in the plot (49) and that 28 (57 per cent) of them were native. Total native cover was a healthy 44 per cent. Reflecting the nature of the site, the most common growth form was low perennial grasses (less than 0.2 m). The highest cover was provided by native grasses followed closely by litter or dead vegetation, and then bare earth. The condition of two mature trees (both eucalypts) in the plot was recorded as good. A few naturally recruited eucalypt seedlings were also recorded in the plot which was good news for the volunteers. Terrestrial habitat condition was also surprisingly good (60 per cent) – this indicator accounts for the presence of shrubs, branches, leaves and bark on the ground as well as trees. Anecdotal evidence of very good revegetation success was confirmed with the result of an 80 per cent survival rate for planted seedlings. It will be of some interest to measure any changes in species diversity and structure over time, and in particular, any decline in the proportion of exotic groundcover.

The Friends of Mt Majura volunteers found the Vegwatch monitoring a very useful exercise. It gave them the chance to stop and take a detailed look at the site, as well as a confidence boost that management activities appeared to be delivering the desired outcomes. It was also a great opportunity for volunteers to identify and become more familiar with the plant species occurring in the area. Over the longer term, it is anticipated that Vegwatch data will provide the group with evidence to support the effectiveness of their management efforts.



Aerial view of the Mt Majura Vegwatch plot. Image: W. Pix

Friends of Mt Majura volunteers recording species diversity during Vegwatch training Nov 2014. Photo: J. Lynch.

Photopoint monitoring: view of the Friends of Mt Majura Vegwatch plot from northwest corner looking towards the southeast. Photo: W. Pix.

Issues

While the community groups using the program have been largely enthusiastic, like all such programs, on-going support is required. Accuracy and consistency of data collection over time and between surveyors is key to the ability to compare results over time. There is a clear need to provide refresher training to groups and to help source professional assistance with species identification.

As has been shown with the Waterwatch and Frogwatch programs, support in the form of a paid coordinator is essential to ensure monitoring is undertaken regularly and consistently. Feedback to the community volunteers undertaking the monitoring is critical to the program being maintained season after season. A Vegwatch monitoring session requires a not insignificant commitment of time (a minimum of four hours for a group of three or more people one to two times a year), and at least some knowledge of plant groups and species. To maintain this level of support and enthusiasm volunteers need to see their results reported on regularly and explained in the wider context in order to see the value of the time and effort they are putting in.

Conclusions

The Vegwatch program has established the groundwork for a robust and achievable vegetation monitoring program that can be undertaken by community volunteers and landholders, and also used to feed back information on the effectiveness of NRM projects and on-ground works. To gain the most out of such a program, data must be publicly available and easily interpretable to guide improvements in management designed to retain biodiversity values on a range of land types, as well as maintain the enthusiasm and commitment of the volunteers collecting the data.
The Molonglo Catchment Group is seeking to gain further support to continue this program into the future, not only in terms of funding, but, importantly, to ensure there is recognition for the value of this community citizen science program in measuring the impact of on-ground management undertaken to maintain our biodiversity heritage.

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Copies of the manual (hard copy or CD) can be obtained from Sarah Sharp (sarahsharp@grapevine.net.au) or downloaded from: http://www.molonglocatchment.com.au/Documents/News%20Page/ACT%20Vegwatch%20Manual.pdf.

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Citizen science and conservation: Are volunteers the way of the future for effective decision-making?

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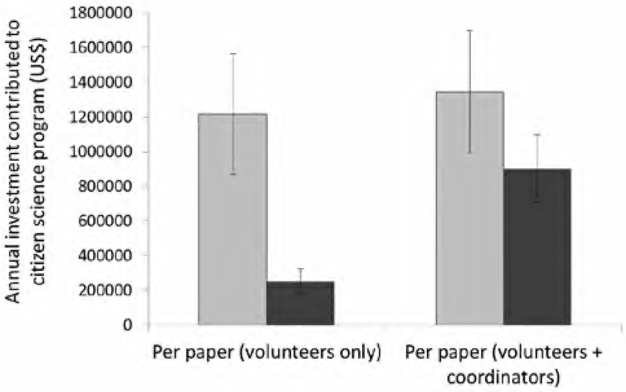
Citizen science, the involvement of volunteers from the general community in academic research, has become increasingly important in conservation science. Aided by the internet, the popularity and scope of citizen science appears almost limitless. For citizens, the motivation is to contribute to science and better conservation outcomes. For researchers, citizen science provides an opportunity to gather information that would be impossible to collect because of limited resources.

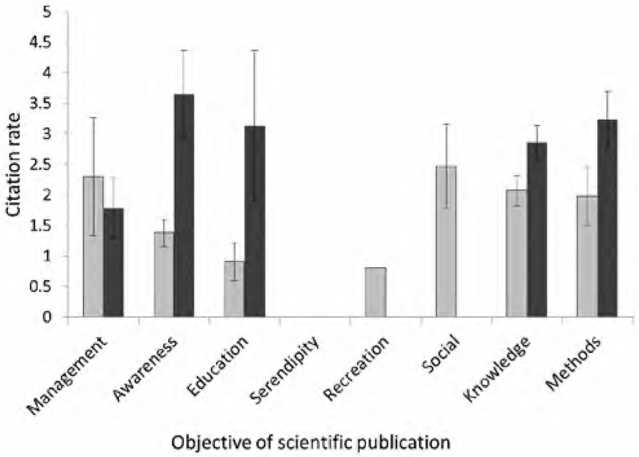
So, how much of a contribution is citizen science actually making? We recently reviewed scientific publications applying citizen science bird monitoring programs to determine their influence in the scientific literature, and whether or not they are useful for informing management decisions (Tulloch and Szabo 2012, Tulloch et al. 2013). Our review revealed two key things. First, there is a massive in-kind contribution in terms of survey investment by volunteers, an investment that is unlikely to be possible in most scientific projects. Second, the way in which a citizen science program is designed and delivered is key to whether it can inform conservation and management decisions.



Mean (SE) annual investment by volunteers and with coordinators added relative to publication output, in cross-sectional (light grey bars) and longitudinal (dark grey bars) programs. This kind of investment is impossible for the majority of scientific research papers.

Real benefits

Although there has been criticism in the past about the ability of citizen science to deliver real conservation benefits, we showed that not only are multiple types of citizen science protocols useful for informing decisions, but also that they have a range of side benefits that most scientific monitoring programs fail to achieve. These benefits include increasing public awareness of conservation, education, recreation, social and economic research, and learning to improve methods of monitoring and evaluation.



The impact (in terms of number of times cited per year) of different kinds of citizen science programs relative to the objective for which they were used in scientific publications. Light grey bars represent cross-sectional schemes – collections of surveys of many species contributed by volunteers over a set period of time – such as Atlases. Dark grey bars represent longitudinal schemes – on-going stratified monitoring of sites that require more coordination – such as Breeding Bird Surveys.

The most-frequent application of citizen science research was to improve ecological knowledge – learning for learning's sake. This knowledge informs management decisions that require an underlying understanding of how species respond to different environmental conditions, or why species occur in one location and not another.

As we struggle to address all of the threats affecting our declining biodiversity, particularly in sparsely populated and difficult-to-access places like much of Australia, citizen science will become the only practical way to achieve the geographic extent required to document ecological patterns and address ecological questions at scales relevant to species range shifts, migration patterns, disease spread, broad-scale population trends, changes in national and state policy, and impacts of environmental processes like climate change.

Tracking invasion

In our review, the study with the highest influence on the scientific literature (a whopping 21.5 citations per year on average) investigated the emergence and impacts on birds of the deadly West Nile Virus in the US (LaDeau et al. 2007). Engaging citizen scientists is a perfect solution for tracking and perhaps even managing the spread of invasive species and diseases. One example is a recent application which gathers on-ground observations by citizen scientists to track the invasive grey squirrel across the UK (http://maps.biodiversityireland.ie/#/Home) – these observations then inform managers where to best tackle the invasion front. With attention in Australia focused on how native species and invasive species such as cane toads might spread under future changed climate conditions, citizen scientists are primed to play an increasing role in managing their spread before it is too late.

Of course, gaining knowledge about management usually requires ancillary information about that management (e.g. grazing, fire or logging). This is rarely a part of citizen science, so the future success of citizen-science programs hinges on good collaboration with organisations collecting landscape-level data that might be combined with the huge monitoring efforts of citizen scientists.

Making the most of citizen science

To ensure citizen science data are used to their full potential, we recommend the following:

1. **That we learn:** Elements of successful citizen science protocols are incorporated into future programs, emphasising:
    a. fine-scale data collection,
    b. temporal replication that covers the full range of habitats or land use types, and
    c. communication of data needs with volunteers.
2. **That we maintain quality:** Regional coordinators are in place to maintain data quality.
3. **That we communicate:** Communication between researchers and the organisations coordinating volunteer monitoring is enhanced, with monitoring targeted to meet specific needs and objectives.
4. **That we seek to fill the gaps:** Application of citizen science programs to under-explored objectives and species is encouraged, and data are made freely and easily accessible.

One exciting example of successful communication and a growing citizen-science network is the Australian program 'Fungimap' (www.fungimap.org.au/), which encourages citizens to report and send in photos of some 220 target species. This effort led to the one of the first ever fungi ID guides in the world.

But it's not just bird lovers (or even fungi lovers) who will be contributing to this new movement. With the emergence of new technologies, greater networking and the rise of open-access science, citizens of all types will have the capacity to participate in citizen science and play a role in monitoring and managing biodiversity into the future. A more formalised citizen-science enterprise, complete with networked organisations, associations, journals and cyber-infrastructure, will advance research and further educate the public.

This is already becoming possible with programs such as eBird (see Birding into the 21st Century), the Atlas of Living Australia's Citizen Science portal (www.ala.org.au/get-involved/citizen-science/) and recent formation of the Australian Citizen Science Association.

This article was originally published in Decision Point*, the magazine of the Environmental Decisions Group, an Australian network of conservation researchers working on the science of effective decision making for better conservation of biodiversity.* Decision Point *is available at www.decision-point.com.au.*

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Considerations for large-scale biodiversity reforestation plantings. Part 4: maintenance

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Introduction

This article is the fourth in a series discussing considerations needed in large-scale tree planting for biodiversity outcomes. The previous article discussed project implementation – including plant procurement, site preparation and planting techniques. Once the project implementation is complete, the maintenance period begins. This article discusses this phase, including considerations for the maintenance contract, activities, interventions and project management issues that are fundamental in the delivery of biodiverse forests.

Maintenance contract

Following the planning and implementation phases of large-scale reforestation projects, maintenance will typically be the third contract component with associated milestone payments.

Some contracts may have a three month, or similar, establishment phase followed by several years of maintenance. A two year maintenance program is common although much longer timeframes can be required to ensure a forest can establish and start to resemble the intended reference vegetation system. A five year maintenance program is preferred to ensure 'site capture'[1]. Beyond five years, further activities and interventions such as weed management, fire break maintenance and understorey enhancement planting may still be required.

Maintenance programs and budgets will be determined for each site and for the management zones prescribed in the mapping produced in the planning phase. Threatening processes and risks are considered in association with the resources required to manage these threats.

Maintenance program

The maintenance program will have a number of visits per year such as: ten visits in years one and two, eight visits in years three and four, six visits in year five. Declining maintenance frequency over successive years is based on the assumption that management efforts successfully reduce the degrading pressures and that the planted trees achieve site capture. A preferred strategy is to reduce maintenance visits during the cooler months and increase them in the growing season (wet season) when tree plantings are most at risk. Flexibility in the schedule is also important for attending to any unplanned issues as they arise.

The exact maintenance specification will vary depending on the site, management zones and aims of the project. Planting density, access, weed pressure and the type of forest community to be reinstated will all be factors. Some measurable performance indicators typically include tree mortality, average canopy height, percentage of weed coverage, level of acceptable height that exotic grass must be maintained at, and management of natural recruitment.

Establishment period: watering, tree protection, weed management, slashing and replanting

The three month establishment period following planting is often when native tube stock is most vulnerable to mortality. For this reason, a maintenance contract may have provisional items that can be negotiated between the client and contractor as required based on the site and weather. For instance, if a dry period develops during establishment, watering may be necessary – a challenge in bushland and agricultural landscapes, where access for water trucks can be limited. Alternatively, if soil moisture remains favourable and rain is received during the establishment period, provisional watering funds can be retained. Similarly, tree protection may not be specified for installation during implementation, but may be required during establishment. A provisional sum for installation of tree guards may be included if there is a likelihood that browsing will damage growing plants.

After the effort, approvals and costs applied to the planning framework and implementation phase it is critical that the 'as implemented' stocking rates are retained during the establishment and maintenance periods. Replanting should align, as a minimum, with the mortality rate specified in the contract. A 10 per cent mortality rate is a very high, but reasonable target to achieve. Progressively replacing dead or ailing tree stock will retain the target restoration density and ensure the desired canopy structure is realised.

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[1] 'Site capture' refers to sufficient development of the canopy to create shade and debris. Evidence of natural recruitment may also be present in the growing forest.

Left: watering during the establishment phase. Right: slashing is essential to retain access so that tree stock can be maintained (right). Photos: Dan Cole.

Maintenance activities

Typical maintenance activities after the establishment phase include weed control and management, using and checking tree guards, natural recruitment management, watering, formative pruning, thinning of pioneer species (if required, in years four and five), and fauna monitoring.

Weed management

Establishing large tree communities in altered or cleared landscapes will require weed management. The principal aim of any weed management strategy is to control weeds so that they do not impinge on the growth of the planted stock. In large-scale tree plantings, saplings are usually planted in rows and slashing inter-rows will assist in controlling weeds across the site so that the team can target the planted rows and tree stock. Herbicide spraying of planting circles or entire planted rows needs to continue until trees are established and there is a sufficient canopy structure to shade out robust exotic grasses. If tree guards are used and there is weed encroachment within the guard then manual removal is required.

Slashing will generally be required along fences, access tracks and other infrastructure. Several activities can be coordinated in the one maintenance run. For instance, hand weeding in tree guards can be combined with applying grass cuttings after slashing to form a mulch layer around each tree. A wash-down area to remove weed seed from vehicles and machinery will minimise further weed seed distribution through the landscape as much as practicable.

Tree guards: considerations and costs

Numerous products offering physical protection to trees are available. These vary in durability and cost, but can increase maintenance efficiency – essential for large-scale projects. Tree guards provide mechanical protection, but also protect from frost and herbivory as well as from herbicide spray drift. Tree guards can however create maintenance problems when they are displaced by wind, fauna or by acts of vandalism. Resources are also required to remove, freight and recycle guards. The timing for the removal of guards from young trees is critical and will vary between species. It is important to note that if guards are not removed at the appropriate time, tree form can be adversely impacted and removal of guards may be fiddly and waste resources.

Left: steep riparian zones are challenging to maintain at scale. Right: herbicide treatment of planted rows to manage threatening exotic grass. Photos: Dan Cole.

Natural recruitment management

Routine inspections for natural recruitment along with staking and flagging newly identified individuals should be done prior to slashing and weed maintenance activities.

Formative pruning: urban forest and edge treatments

In urban reforestation projects adjoining public parks, formative pruning may be required to comply with Crime Prevention Through Environmental Design (CPTED) guidelines. This will depend on forest set-backs from pathways and infrastructure. Formative pruning to remove lower branches and increase sight lines may need to only be an edge treatment. Incorporating a high density native grass planting along the forest edges can minimise weed pressure. Management of canopy structure near service tracks may also be required so that access is not impeded.

Thinning, replanting and enhancement planting

Thinning of pioneer tree and shrub species in high density reforestation plantings will encourage secondary and mature phase species which can facilitate further natural recruitment or the opportunity for enhancement planting. A second phase of planting can enrich floristic diversity with species (such as rainforest species) unsuitable for inclusion in the primary planting of pioneer and canopy trees.

Watering

Watering is usually necessary to assist the establishment of stock within the first three months of planting. Afterwards, watering will only be needed if very dry conditions occur and it is deemed that significant losses will occur if watering is not undertaken.

Fauna monitoring

Fauna in and adjacent to the site should be monitored and further strategies to prevent herbivory from deer, rabbits or macropods implemented as required.

Maintenance activities need to consider faunal interactions with the project. Photo: Dan Cole.

Project management

Good project management by the principal contractor is key to delivering a biodiverse forest to the client at the conclusion of the maintenance period. Successful project management will endeavor to maintain sites so that reasonable control is retained despite seasonal challenges that may impact works.

Project management is not only about understanding forest ecology, ecological restoration and technical specifications. It is about managing the budget, client relations, difficulties in stock procurement and unforeseen seasonal changes to deliver the agreed outcomes. We will consider this subject in more detail in the next issue.

Concluding summary

Maintaining large-scale reforestation projects requires a collaborative approach between the client and contractor(s) so that challenges impacting the restoration can be resolved with appropriate interventions that may require adaptive management beyond the contract. Contractors must be committed, flexible and well-resourced to undertake maintenance on large-scale biodiverse reforestation projects. In the next issue we examine governance and project management.

Plant Germplasm Conservation in Australia

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ANPC member profile

Mark Richardson

What is your current position?

For the past nine years, I have been working as a botanical consultant and have been involved in a wide range of horticultural and conservation projects in Australia and overseas. My overseas clients have included several newly developing botanic gardens including the Royal Botanic Gardens in Jordan, the Oman Botanic Gardens and the Pha Tad Ke Botanical Garden in Laos. These have been excellent opportunities to encourage clients to take on many of the conservation related aspects that have been developed in Australian botanic gardens. Much of this work has followed on from my earlier involvement with Botanic Gardens Conservation International, managing their projects in the Middle East and Asia.

What are you working on at the moment?

One of the projects I have been working on for the past seven years is the National Arboretum in Canberra. Since it was first developed it has had a strong conservation theme that has attracted interest in both Australia and overseas. The arboretum grows indigenous and exotic species in monocultural plantings and there has already been interest shown in the possibility of harvesting the seed from a number of species in the collection for conservation works. This, in addition to providing information to visitors about the conservation of trees around the world, should make it a valuable resource in the future.

How did you end up working in plant conservation?

I first started working in plant conservation when I was employed as the Curator of Living Collections at the Australian National Botanic Gardens (ANBG) in Canberra. The idea of botanic gardens being involved in plant conservation was already starting to be accepted around the world, and the Director of the ANBG at the time, Dr Robert Boden, was actively promoting its importance. As a result of this influence I made plant conservation an important role of the ANBG's living collection and my career.

How long have you been involved with the ANPC?

Working at the ANBG I felt that part of my role was to encourage a greater involvement by all Australian botanic gardens in plant conservation. Consequently, in the late 1980s I organised a nation-wide review of botanic garden conservation activities. It was a good time to encourage a much greater conservation focus within the botanic garden community.

ANPC Committee member Mark Richardson (right) with Gregory Andrews, the Threatened Species Commissioner, in February 2015. Photo: Jo Lynch.

Initially my involvement was very much focused on *ex situ* conservation with the pre-ANPC conference entitled "Protective Custody? – *ex situ* plant conservation in Australasia". However, as a result of talking to many others I saw it was much more valuable to promote integrated conservation and the importance of both *in situ* and *ex situ* conservation. With that in mind, the ANPC was established in late 1991 for as broad a range of plant conservationists as possible, and the first advisory committee had representation from national parks, botanic gardens, industry and non-government organisations. The first ANPC conference was then held in Hobart and the desired diversity of participants and topics was achieved. I was the ANPC National Co-ordinator until 1996 when I moved to Alice Springs, but I have continued to be a member since then and have been on the ANPC Committee since 2010.

What do you see as ANPC's priorities for the future?

Although it has existed for over 20 years, I think that the ANPC's priorities have not changed greatly since it started. It is still very important that the ANPC continues to remind people about the importance of plants and the need for their ongoing conservation. Getting people to go beyond just animals when thinking or talking about conservation is vital! Given the spread of government and non-government conservation organisations across Australia there is also still a real need to try to keep them all aware of each other and to encourage them to share both their successes and failures. The Australasian Plant Conservation bulletin, ANPC workshops, the biennial plant conservation conferences and the ANPC publications have gone a long way in terms of achieving this goal.

Book review

Photographic Guide to Native Plants of the Australian Capital Territory

by Meredith Cosgrove

Meadow Argus, 2014
360 pages with colour photographs and maps, 210 × 150 mm
Paperback, available from www.meadow-argus.com

This beautifully presented little book uses 1388 colour photographs to provide visual assistance in the identification of 325 flowering plants and two conifers native to the Australian Capital Territory. The nomenclature is right up to date, with modern phylogenetically based families and recently named species – *Coronidium montanum* was named just last year. Assignment of genera to families follows the Australian Plant Name Index and Australian Plant Census, which largely follow the Angiosperm Phylogeny Group arrangement. Some users, conditioned to classically based families, may not recognise Phrymaceae or wonder why *Veronica* is not in Scrophulariaceae. Perhaps a reference to the Angiosperm Phylogeny Group website may have pointed the way to those interested, as well as to name change sceptics, to learn how 'total evidence' is used in modern systematics and taxonomy.

Genera are arranged alphabetically within families, as are species within genera. Most taxa (species and subspecies) occupy one page with images of habit, leaves, flowers and fruit, as well as a brief description and notes on breeding systems, flowering and fruiting times, abundance, preferred habitat, distribution and altitudinal range. Each *Eucalyptus* taxon, because of the inclusion of images of bark and juvenile leaves, spreads over two pages. Bark is also shown for some tree species of *Acacia*. Thumbnail distribution maps (extending outside the ACT boundary to Lake George, part of the Southern Alps and the Tinderry Mountains) use point data from verified herbarium records and the distribution of a taxon over its altitudinal range is presented in a bubble graph. 'Key ID', distinguishing feature(s) by which the plant may be identified, are also included.

Photographic Guide to Native Plants of the Australian Capital Territory
MEREDITH COSGROVE

There are introductory glossaries of botanical terms, with floral arrangements, leaf morphology and *Eucalyptus* characters illustrated in a pictorial glossary, as well as a key to families based on flower colour and floral morphology. Images of major habitats, together with an indication of their altitudinal occurrence, are presented.

At 210 × 150 mm, the guide fits into parka pocket or backpack. Of course a book of this size cannot include the total vascular flora of the region, and there may be some frustration when your species from a distant mountain top does not appear. This is diminished by the listing of all species per genus native to the region not given the full treatment, enabling the user to search elsewhere. Under each genus, inclusion appears to be generally based on abundance. For example, of the 28 species of *Eucalyptus* native to the ACT, 19 are treated; those not included are usually known from few remote populations, such as *E. cinerea* subsp. *triplex* and *E. perriniana*. But I noticed *Pterostylis umbrina* that is known from a single verified occurrence was included. But then orchids are always the spoilt darlings.

All photographs are by the author, remarkably taken within seven years. A wonderful achievement to have these beautifully detailed images of the plants, the genera placed in phylogenetically circumscribed families and the names of taxa 'hot off the press'. Altogether an exemplary field guide.

Ian Telford, N.C.W. Beadle Herbarium, University of New England, Armidale.

News

Blossoming future for delicate native shrub – Delicate Pomaderris

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Known to grow in only two locations within NSW and with less than 100 known plants in existence, the population of the Delicate Pomaderris (*Pomaderris delicata*) has received a life line towards securing its future. This has been achieved in just over 12 months and through a collaboration between three government agencies.

In 2014, the NSW Office of Environment and Heritage (OEH) sought the assistance of the Australian National Botanic Gardens (ANBG) as propagation options from seed were limited and because the small number of *in situ* plants had produced very few seeds in recent years. It was then decided to try propagation by cuttings, and given their expertise in this area, the staff of the Australian National Botanic Gardens were put to the task.

One year on the ANBG had successfully grown almost 600 healthy plants – all grown from the original cuttings. The Goulburn Mulwaree Council then stepped in to provide a home on its land for these shrubs in south eastern New South Wales – one between Goulburn and Bungonia and the other south of Windellama.

Following establishment in the ANBG nursery, the plants were then hardened off to give them the best chance of survival in their harsh environment. In May this year a group of local volunteers joined the staff from Goulburn Mulwaree Council, OEH and the ANBG to plant over 500 of these shrubs at the two endemic sites.

As a backup, the ANBG is keeping a selection of the genetic representatives in their Living Collection for future research and potential landscape enhancement plantings. This successful initiative will provide guidance for future threatened species recovery actions and open the door for similar efforts where seed is unavailable or is challenging to germinate.

Pomaderris shrubs only occur in Australasia and of the 70 known species, 31 have extremely restricted habitat and range; most of these are listed as threatened under various legislations. The pomaderris may be a relic of past climates and fire regimes, and with further investigation, could provide indications of how other Australian plants will respond to our changing climate in the future. Due to their habit as attractive, compact and hardy shrubs, they also have great commercial potential in horticulture.

These recent plantings are a significant step towards securing the future of a priority threatened species and the co-operative project is an example of how local, state and federal governments can work together to secure important conservation outcomes.

Left to right: The attractive compact blossom of Pomaderris; planting Pomaderris along a roadside near Tarago; Keith McDougall inspecting Pomaderris *in situ*. Photos: ANBG.

Workshop report

Provenance workshops: ANPC NSW grand seed tour

MARTIN DRIVER
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A series of seven workshops across NSW has brought together over 300 people from a wide range of fields to learn and discuss some of the issues of native seed supply management for self-sustaining vegetation communities.

The workshop series was co-ordinated by ANPC Project Manager Martin Driver and funded by the NSW Environmental Trust. It brought together Dr Linda Broadhurst from CSIRO and Dr Maurizio Rossetto from The Royal Botanic Gardens, Sydney to convey the latest lessons and understanding on native plant seed science, genetics and issues of climate change.

The seven workshops were held in Armidale, Lismore, Coffs Harbour, Orange, Yass, Wagga and Mt Annan in western Sydney in conjunction with regional and State Local Lands Services (LLS) offices and staff.

Collation of the workshop evaluations are yet to be completed but there has already been very positive feedback regarding the presentations and format. There have also been suggestions and ideas about the need to extend the knowledge and strategies outlined into more detailed local support workshops to meet regional seed needs and project support.

Participants at the Provenance workshop in Orange. Photo: Central Tablelands LLS

Dr Maurizio Rossetto from the Royal Botanic Gardens, Sydney, presenting at the Provenance workshop at the Australian Botanic Garden Mt Annan. Photo: Greater Sydney LLS

While issues of plant genetic adaptation to rapid climate change were a feature of workshop discussions, there was also much concern raised on the resilience of regional vegetation programs to rapid funding declines. One consistent theme was that of investing limited resources into quality assurance of genetic seed supply as a direct means of ensuring quality vegetation outcomes, rather than just quantitative measures.

Electronic versions of the presentations are to be distributed to all participants and LLS offices, and are available upon request to anpc@anpc.asn.au.

While some workshops were oversubscribed every effort will be made to follow up those that were unable to attend and look at the possibility of future workshops.

ANPC would particularly like to thank presenters Linda and Maurizio on the huge commitment and effort in time and travel to deliver the workshops. We would also like to thank the regional LLS staff in reaching their many and varied networks and interested parties for arranging venues and catering. We look forward to working further with you all in the future and in establishing closer ties to meet your regional vegetation goals.

Research roundup

COMPILED BY KIRSTEN COWLEY

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Contributions to Research Roundup are welcome, and should be sent to Kirsten Cowley at the above email address using an email subject heading "APC Research Roundup" or similar. Their inclusion will be subject to available space.

ASBS
2015

Australasian Systematic Botany Society Annual Conference

Building Our Botanical Capital

29 November–3 December 2015

CSIRO Discovery Centre, Black Mountain

The Society will be holding its conference in Canberra for the first time in 25 years, providing a forum for presentations and workshops on developments in plant systematics. There will be a particular focus on emerging methods of phylogenetic analysis and on making biological collections data accessible. A conference fieldtrip will also be run in addition to a program of social events for delegates.

Early-bird registrations close **Friday 16 October 2015.**

For more details visit the conference website at asbs.org.au/cbr2015

Australian Seed Bank Partnership
National Seed Science Forum

Australian Botanic Garden, Mount Annan, NSW
14–16 March 2016

AUSTRALIAN SEEDBANK PARTNERSHIP

The National Seed Science Forum will be a rare opportunity to bring together leading botanical and agricultural institutions, seed scientists, and conservation and restoration experts to share ideas that showcase the importance of seed science to the future of plant conservation and food security in Australia.

The Australian BOTANIC GARDEN Mount Annan

Australian Network for Plant Conservation Inc

Australian Grains Genebank

WHERE: Hosted by the Australian Botanic Garden Mount Annan, the Forum will be held at the Australian PlantBank, in collaboration with the Australian Network for Plant Conservation and the Australian Grains Genebank.

WHEN: The Forum will commence with an evening event on Monday 14 March, with the main science programme being presented on 15–16 March 2016.

WHO: An exciting programme of local and international experts is planned, speaking on seed conservation, storage, preservation and germination. Keynote speakers for the Forum are:

- **Dr Christina Walters:** Research Leader in Plant Germplasm Preservation Research at the National Center for Genetic Resources Preservation in the United States
- **Professor Kingsley Dixon:** Curtin Professor at Kings Park and Botanic Garden in Perth
- **Professor Angela Moles:** Professor at the School of Biological, Earth and Environmental Sciences at UNSW

CALL FOR PROPOSALS

Forum organisers are now calling for proposals for the Forum programme under the four key themes:

- Theme A: Dormancy and germination
- Theme B: Seed storage, conservation and utilisation
- Theme C: Establishment and management
- Theme D: Seed ecology

Submissions should cover descriptive or mechanistic seed science, theoretical seed research, and/or their application for effective seed use are encouraged from conservation, restoration and agricultural perspectives. Visit http://seedpartnership.org.au/seedscienceforum for more details.

Proposal submissions for the Forum close on 4 October 2015

KEY DATES

Abstract submissions close	4 October 2015
Announcement of programme details	16–20 November 2015
Early-bird registration closes	11 December 2015
Forum registration closes	29 February 2016
Forum	14–16 March 2016

Registration opening date will be advised shortly. In the interim, please email: info@seedpartnership.org.au to register for Forum announcements.

RTBG

ANDREW CRAWFORD, DPAW

ANNE COCHRANE, DPAW

JOHN GOLLINGS

The Australian Seed Bank Partnership is a national effort to conserve Australia's native plant diversity through collaborative and sustainable seed collecting, banking, research and knowledge sharing. **Our vision** is a future where Australia's native plant diversity is valued, understood and conserved for the benefit of all.